Impact of three lateral root types identified in pearl millet on water uptake

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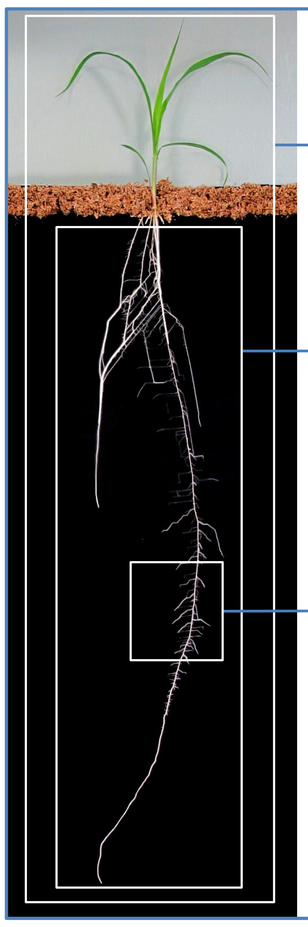
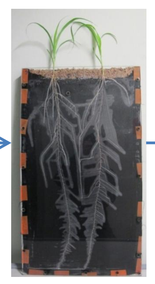
Context Diversity has been observed in the anatomy and growth patterns of lateral roots in cereals. This may impact water uptake and could therefore increase cereal performances under drought. This study focuses on pearl millet, a key crop for food security especially tolerant to drought.
Objectives The objective was to provide an integrated description of pearl millet lateral root development at early stages and to assess the impact of the existing diversity among lateral roots on water uptake using simulations.

Material and methods



Growth conditions: Sandy soil, initially wet, transpiration of 40cm³/day

Phenotyping in rhizotron



Digitalization with SmartRoot

Root development dynamics

RootTyp

Simulation of root system architecture

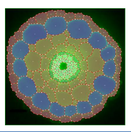
Transversal sections

Root anatomy

Crown root
Scale bar: 100µm

Haagen-Poiseuille law

Axial conductance



CellSet

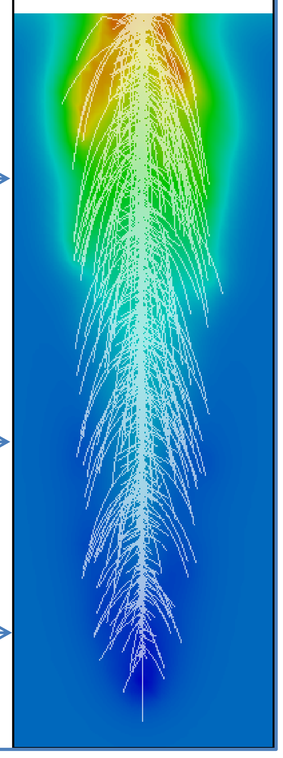
Digitalization

Explicit cross section hydraulics

Radial conductance

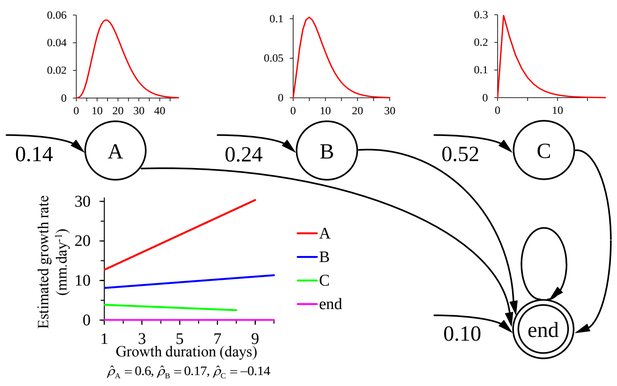
In the lab
In silico

Water uptake simulation with R-SWMS

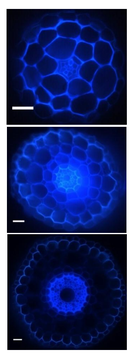


Results

Using a semi-Markov switching linear model lateral root (LR) growth profiles cluster into three groups.



Three distinct LR anatomies were found which correlate with groups based on growth profiles ①

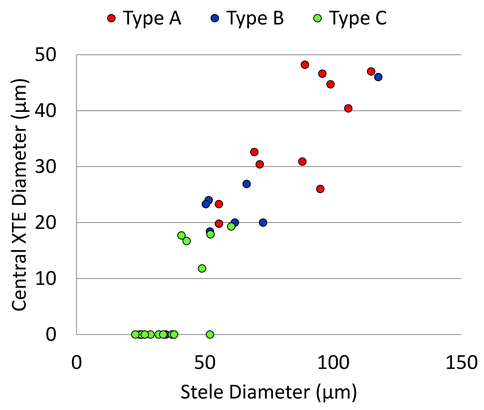


Ø 100 µm, 2 periph XTE

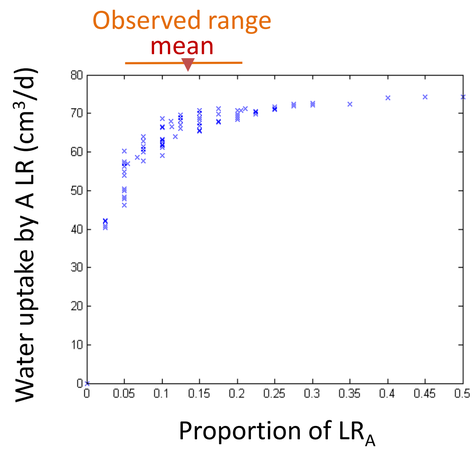
Ø 250 µm, 1 central + 3 periph XTE

Ø 380 µm, 1 central + 7 periph XTE, aerenchyma

Scale bar: 20µm



Simulations indicate that LR_A take up most of water. Further simulations show that this contribution to water uptake reaches a plateau around the observed proportion of LR_A. ③

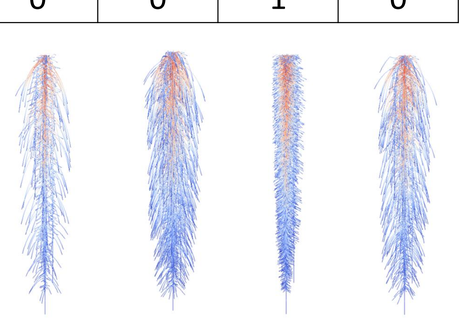


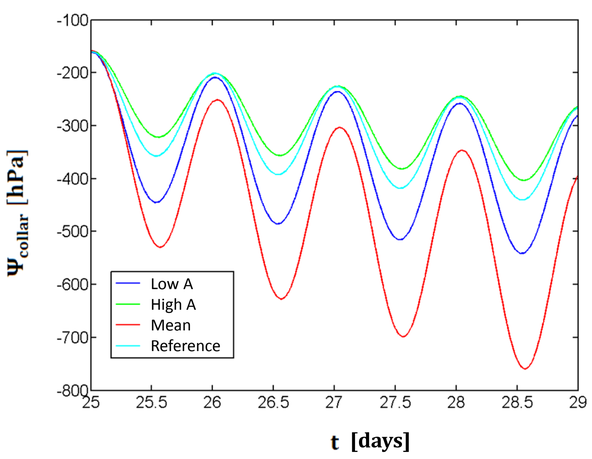
with $0 \leq \%A \leq 50\%$, $\%A \leq \%B$ & $0 < B$

Simulations were done with **reference** architecture, with **extreme observed** proportions of LRs and with a synthetic "**mean + sd**" homogeneous behavior for all LRs. Transpiration is fixed (40cm³/d) while Ψ (water potential) at the collar depends on the ability of the root system to take up water. ②

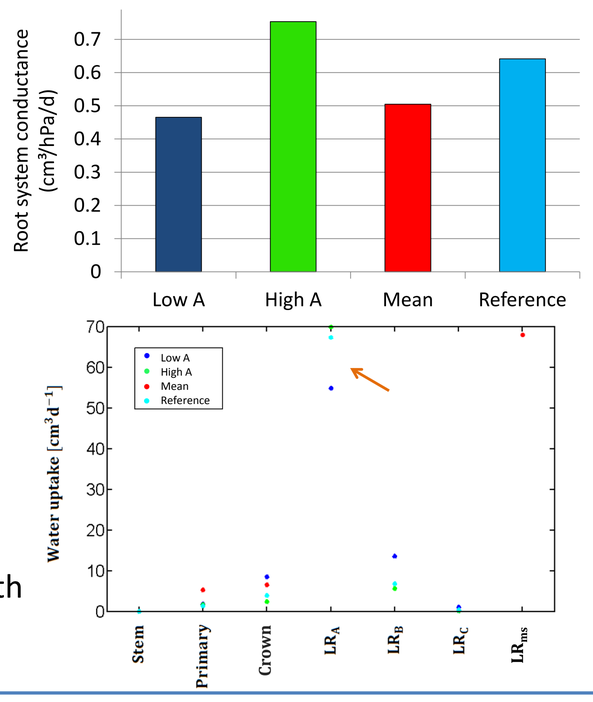
	Low A	High A	Mean	Ref.
LR_A	0.05	0.21	0	0.14
LR_B	0.18	0.30	0	0.24
LR_C	0.77	0.49	0	0.62
LR_{ms}	0	0	1	0

Simulated root systems (RootTyp)





Plants with only one type of LRs would experience drought earlier than those with three types, regardless of proportions



Conclusion

→ **Three types of LRs** identified in pearl millet based on **growth profiles & anatomy**
→ Existence of three distinct types would **delay drought sress**
→ **Largest LRs** contribute the most to water uptake and their **contribution reaches a plateau** around the usually observed proportions of LRs

Passot, S., Gnacko, F., Moukouanga, D., et al. (2016). Characterization of Pearl Millet Root Architecture and Anatomy Reveals Three Types of Lateral Roots. *Front. Plant Sci.* 7, 1–11.
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Presented at
InterDrought-V
Hyderabad International Convention Center (HICC)
Hyderabad, India
21-25 February, 2017